

## CLAIMS

*what is claimed is:*

1. A method of depositing a metal-containing capping layer on metal portions of a substrate containing a layer of metal and dielectric, the method comprising:
  - (a) receiving the substrate containing the layer of metal and dielectric;
  - (b) etching metal from the substrate to a position below an upper level of exposed dielectric in the layer; and
  - (c) forming the capping layer on at least exposed metal portions of the substrate by electroless deposition.
2. The method of claim 1, wherein the metal of the layer is copper or a copper alloy.
3. The method of claim 1, wherein the capping layer comprises a refractory metal.
4. The method of claim 1, wherein the capping layer comprises cobalt.
5. The method of claim 1, wherein the metal of the layer is etched to a position below the level of the exposed dielectric that is approximately equal to or lower than a target thickness of the capping layer.
6. The method of claim 1, wherein the capping layer is between about 30 and 500 Angstroms thick.
7. The method of claim 1, wherein etching metal from the substrate comprises contacting the substrate with an etching solution.
8. The method of claim 7, wherein the etching solution oxidizes the metal of the substrate to a metal oxide.
9. The method of claim 8, further comprising removing the metal oxide so that the exposed metal portions attain said position below the upper level of the exposed dielectric.

10. The method of claim 9, wherein removing the metal oxide comprises contacting the substrate with an oxide etchant that selectively removes the metal oxide and not the metal.
11. The method of claim 10, wherein the oxide etchant comprises glycine.
12. The method of claim 10, wherein the oxide etchant comprises a complexing agent for ions of the metal.
13. The method of claim 9, wherein oxidizing the metal of the substrate to a metal oxide and removing the metal oxide takes place in one etching solution.
14. The method of claim 8, wherein the etching solution comprises an oxidizing agent selected from the group consisting of a peroxide, a permanganate, ozone, and a persulfate.
15. The method of claim 8, wherein the etching solution further comprises a corrosion inhibitor.
16. The method of claim 7, wherein the etching solution comprises an acid.
17. The method of claim 7, wherein the etching solution further comprises a surfactant.
18. The method of claim 7, wherein the etching solution directly etches the metal of the substrate without producing an insoluble metal oxide.
19. The method of claim 18, wherein the etching solution is acidic.
20. The method of claim 19, wherein the pH of the etching solution is between about 1 and 4.
21. The method of claim 18, wherein the etching solution comprises a corrosion inhibitor.
22. The method of claim 18, wherein the etching solution comprises a complexing agent.

23. The method of claim 18, wherein the etching solution comprises a surfactant.

24. The method of claim 7, wherein contacting the substrate with an etching solution comprises dipping, spraying or using a thin film reactor.

25. The method of claim 1, wherein etching metal comprises contacting the substrate with an oxidizing gas that oxidizes the exposed metal to a metal oxide and further contacting the substrate with a metal oxide etching agent to remove the metal oxide.

26. The method of claim 25, wherein the oxidizing gas comprises oxygen.

27. The method of claim 26, wherein the oxidation occurs at a temperature between about 200 and 300 degrees Celsius and at a pressure between about 50 and 180 Torr of oxygen.

28. The method of claim 1, further comprising performing a post-etch treatment of the substrate prior to forming the capping layer.

29. The method of claim 28, wherein the post-etch treatment of the substrate involves cleaning the etched metal portions of the substrate prior to forming the capping layer.

30. A method of claim 1, wherein forming the capping layer on the etched metal portions of the substrate by electroless deposition comprises:

forming a metal nucleation layer on the exposed metal portions of the substrate by electroless deposition from a first solution comprising metal ions; and

forming a bulk metal layer on the metal nucleation layer by electroless deposition from a second solution comprising metal ions and a reducing agent that promotes electroless deposition on elemental metal surfaces.

31. A method of claim 30, wherein the metal capping layer comprises cobalt.

32. The method of claim 30, wherein the first solution comprises cobalt ions and a water-soluble borane compound.

33. The method of claim 30, wherein the reducing agent of the second solution comprises a hypophosphite.

34. The method of claim 1, further comprising performing a post-deposition anneal of the capping layer.

35. The method of claim 1, further comprising nitriding the capping layer.

36. The method of claim 1, wherein the substrate received in (a) comprises exposed regions of dielectric.

37. The method of claim 1, wherein the substrate received in (a) comprises metal covering the upper level of dielectric.

38. A method of depositing a metal-containing capping layer on metal portions of a substrate containing a layer of metal and dielectric, the method comprising:

receiving the substrate containing the layer of metal and dielectric;  
etching metal from the substrate to a position below an upper level of exposed dielectric in the layer; and  
forming the capping layer on at least exposed metal portions of the substrate.

39. The method of claim 38, wherein forming the capping layer comprises a process selected from the group consisting of physical vapor deposition (PVD) followed by planarization, selective chemical vapor deposition (CVD) on the exposed metal portions of the substrate, atomic layer deposition (ALD), selective reduction of an organometallic precursor from a supercritical solution, and electroless deposition.

40. The method of claim 38, wherein the capping layer comprises a material selected from the group consisting of cobalt, palladium, ruthenium, platinum, tungsten, lead, cadmium, tantalum, tantalum nitride, nickel, titanium, titanium nitride, molybdenum, and combinations and alloys thereof.

41. The method of claim 40, wherein the capping layer further comprises a non-metallic element selected from the group consisting of boron, phosphorus, carbon, silicon, nitrogen, and sulfur.

42. The method of claim 38, wherein the metal the layer in the substrate is copper or a copper alloy.

43. A method of etching metal portions of a substrate containing a layer of metal and dielectric, the method comprising:

receiving the substrate containing the layer of metal and dielectric; and

etching metal from the substrate to a position below an upper level of exposed dielectric by contacting the substrate with an etching solution comprising between about 0.05% and 15% glycine by weight and between about 0.5% and 20% peroxide by weight, at a pH in a range of between about 5 and 12.

44. The method of claim 43, wherein the peroxide is  $H_2O_2$ .

45. The method of claim 43, wherein the etching solution has a pH in a range of between about 6 and 10.

46. The method of claim 43, wherein the etching solution comprises about 1% by weight glycine and about 3% by weight  $H_2O_2$ .

47. The method of claim 43, further comprising forming a capping layer on the etched metal portions of the substrate.